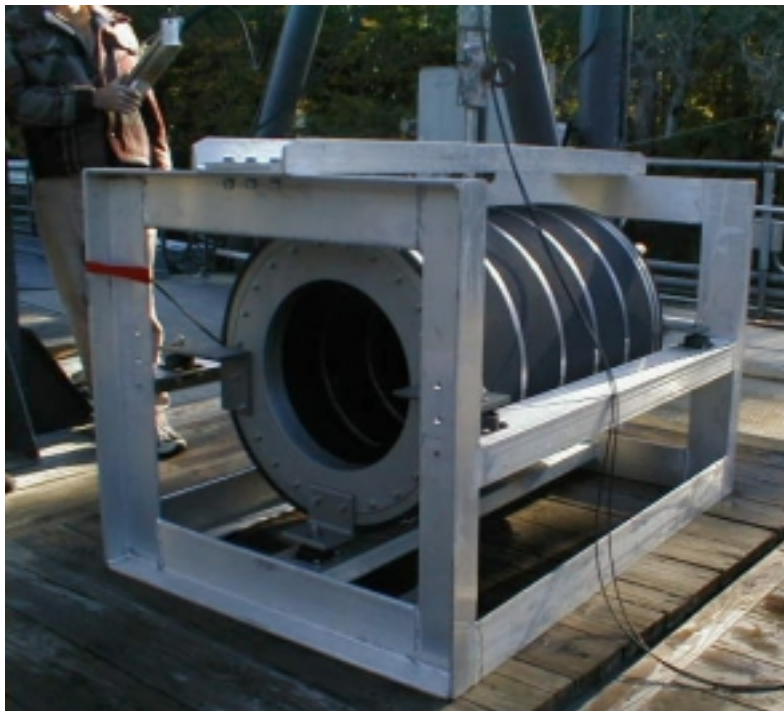


The Naval Research Laboratory's New Deep-Towed, High-Resolution Seismic System

A New Seismic System To Support
Detailed Investigations of Marine Sediments
to Full Ocean Depths



Helmholtz Resonator Source During Acceptance Tests

BACKGROUND:

This seismic system has been designed specifically to support investigations of the structure and physical properties within the upper 1 km of marine sediments. Its unique design allows it to operate to full oceans depths (~6km) without any degradation in capabilities.

The system is based on over 15 years experience with the design, construction and operation of deep-tow, high-resolution seismic systems. The original system, known as the Deep Towed Acoustics/Geophysics System (DTAGS) has been used by the Naval Research Laboratory (NRL) to study marine sediments in the ocean basins, near oceanic ridge crests, and within many areas where natural gas hydrates are located. The new system builds on the knowledge gained over the years with improved performance, navigation capabilities, and reliability.

Even with these improvements, the fundamental advantage of deep-tow, high-frequency technology for geotechnical surveys for petroleum drilling in deep-water or for exploitation of new resources such as methane hydrates is based on the fundamental principal that deep-tow geometries provide a smaller Fresnel zone and greater sampling in wavenumber space with shorter, more manageable arrays.

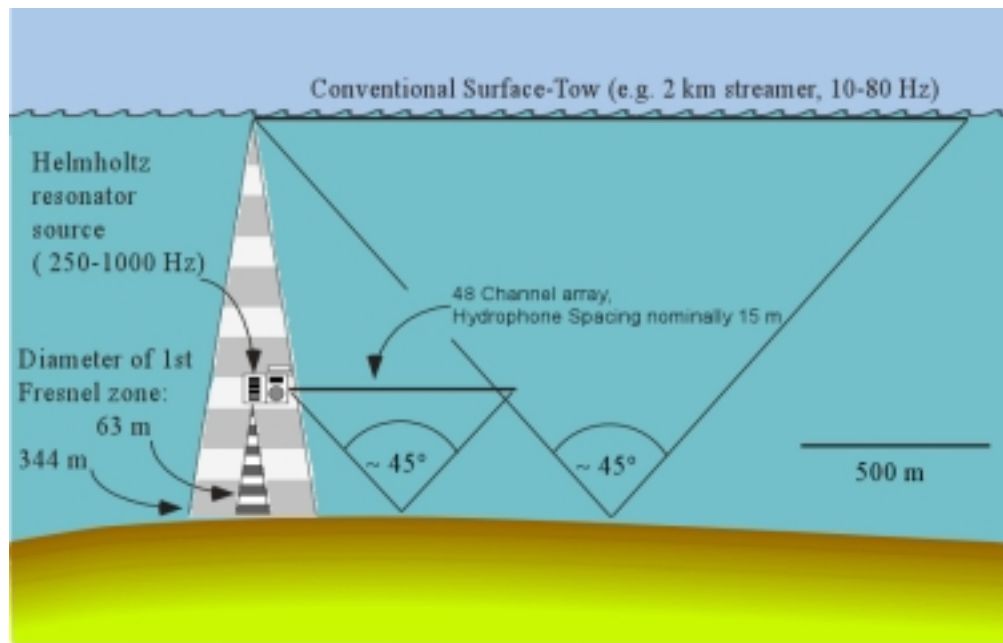
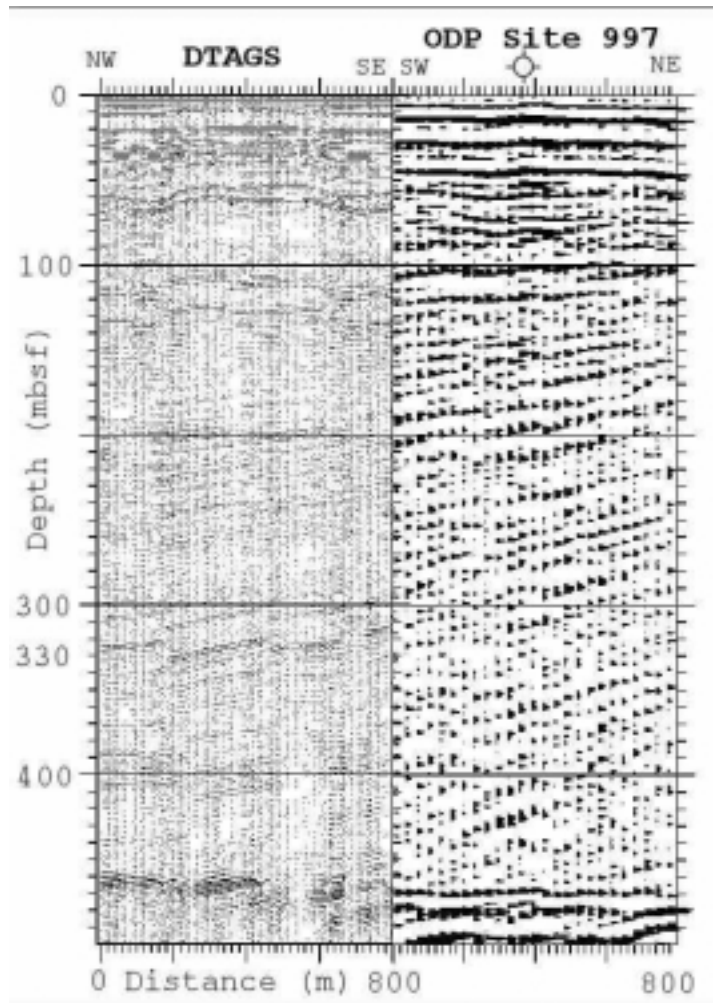


Figure 1: Comparison of Conventional and Deep-Tow Geometries

The performance of the original deep-tow seismic system (DTAGS) leads many to believe in the concept of high-resolution seismic systems



The improvement in resolution of geologic structure is obvious in the above figure, which compares data taken with NRL's DTAGS with that taken by a high-resolution surface-tow system. These data sets were taken within 1 km of each other near the crest of the Blake Ridge (~2km water depth). Note that the strong reflection horizon seen at ~460m depth in the surface-tow data is revealed as being discontinuous with the DTAGS data. This horizon marks the base of the hydrate stability zone (the reflector is often referred to as the Bottom Simulating Reflector (BSR) because it marks the pressure-temperature boundary of hydrate stability. Note also that data from DTAGS resolve geologic faults that extend from the BSR (~460m depth) to the seafloor. This information required that models for dissociation of hydrates be modified to include flow through these faults.

Technical Advances:

Improvements in design incorporated into this system relative to the original system (DTAGS) include:

24-bit Sigma-Delta A/D conversion at each hydrophone:



Figure 2: A/D Converter - hydrophone module

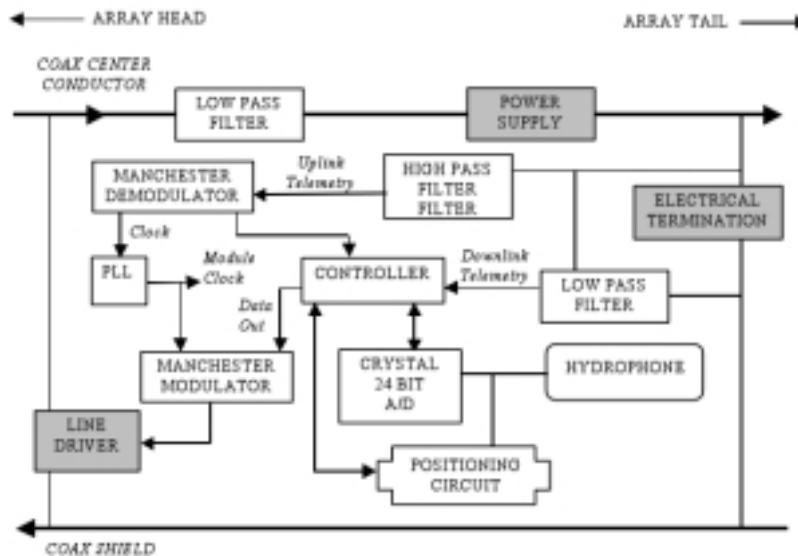


Figure 3: Block Diagram of A/D Module

The 24-Bit linear conversion increases resolution and provides the dynamic range required. Note that this design significantly simplifies the configuration of the hydrophone cable; this simplification will provide improved reliability for deep-tow operation.

Improved Helmholtz Resonator Source:

Several improvements have been made to the Helmholtz resonator source. The first of these is increased bandwidth. The new source increases the source bandwidth from 250Hz – 650Hz to 250Hz – 1kHz. The increased bandwidth was achieved without any decrease in signal level. This upgrade will allow scientists to resolve horizons more accurately and will further refine the capabilities of the already unique seismic system.

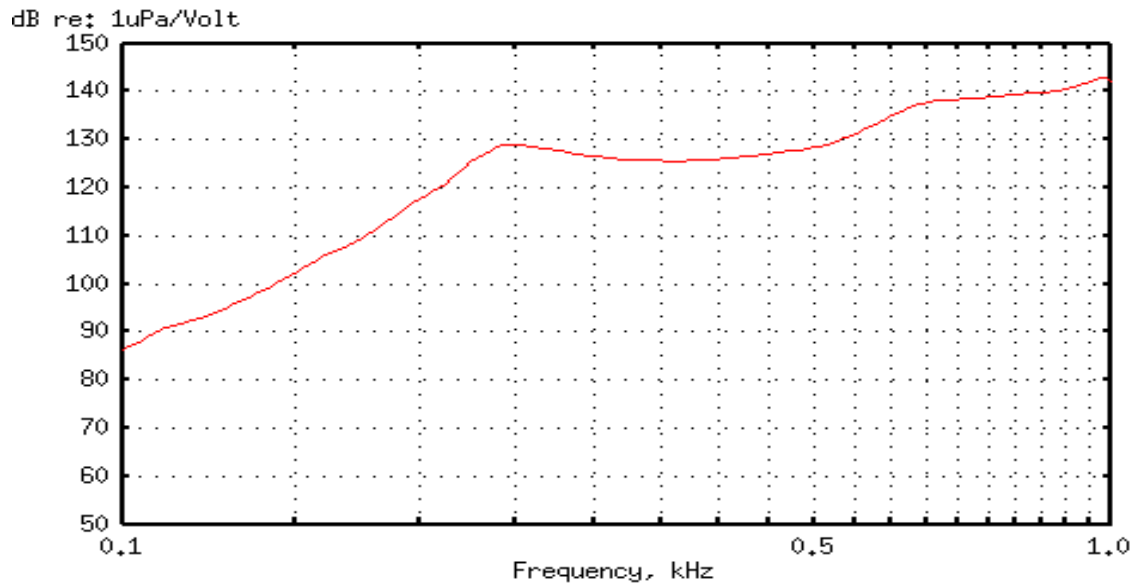
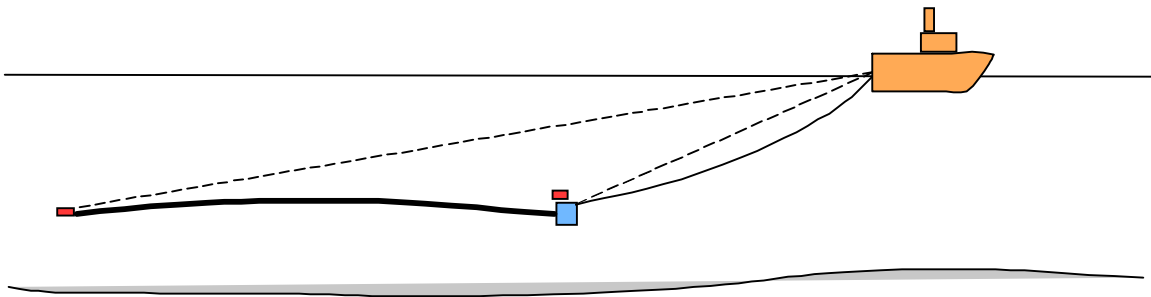


Figure 4: Spectral Response of New Source (low voltage input used for test – no equalization.)

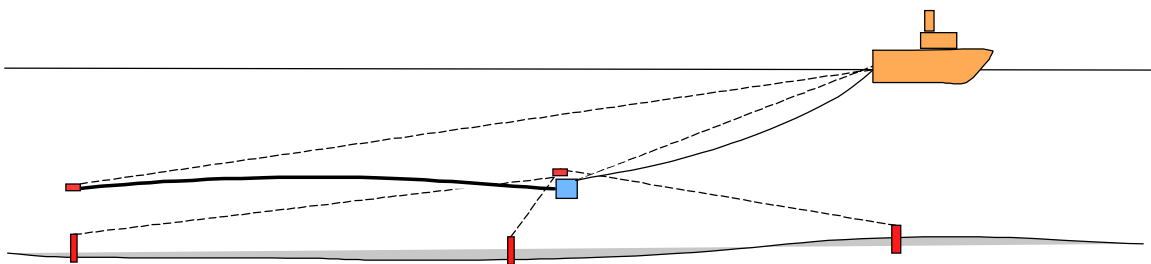
The improved bandwidth also will provide improved resolution of thin “layers” within the sediment column. This improvement will support better resolution of anomalous geoacoustic response in water depths ranging from intermediate (shelf slope) to deep-ocean (~6000m).

Improved Long and Short baseline Navigation Capabilities

The system now includes connectors and internal logic making it possible to directly apply ultra short-baseline (SBL) or short-baseline (SBL) transponders to the towed system. This capability allows users to locate the source and tail of the array with the transponders mounted on the system communicating with industry standard topside equipment.



Support for Long baseline (LBL) navigation capabilities also is included with the system. Again, the system is configured to be compatible with most commercial grade transponder navigation systems. Of course, combinations of navigation (USBL and LBL, for example) are supported.



Therefore, industry standard, deep-water navigation capabilities are available with this system. This allows users to meet their positioning needs to the degree required for the job at hand. Future improvements include support for Inverted Short Base Line (ISBL) navigation for improved deep-water operations.

Overall System Specifications

Seismic Array:

48 channels
15m hydrophone separation (nominal)
Solid core construction

Hydrophones:

Sensitivity 20 volts/bar or -194 dB re: 1 volt/ μ Pascal
Self noise 0.07 microbar RMS
Dynamic range 117 dB (peak to RMS noise)
Frequency response 2 Hz to 3000 Hz
Total harmonic distortion < -90 dB
Directivity omni-directional to 10 kHz in X-Y and X-Z planes

Helmholtz Resonator Source:

Frequency Band: 250Hz – 1kHz
Source Level: 197 dB // 1mPa @ 1m.
Source Signal User programmable sweep 150ms to 250ms in length, 4-cycle 500 Hz tone for testing.
Size: 1m Diameter - 1.6m Height
Weight 7962 N in air

Bottom Electronics/Control System:

Control system Programmable microprocessor
Telemetry Supports 500 μ sec seismic data sample rate plus engineering/navigation data. Commands from topside transferred to microprocessor via low-speed downlink. All via coaxial cable.
Power Power supply and signal control for source and array.
Interfaces Two (2) Array interfaces, interface to external control modules including short baseline and long baseline subsystems for navigation.

Topside Electronics/Control System:

Control System PC based acquisition and monitoring system.
Data Processing PC based, linked via 100 Mbit Ethernet.
Power DC Power Supply to support Bottom Electronics/Control System via coaxial data cable.
Data Recording Data are monitored in “real-time” for quality control and stored on industry compatible media in SEG-Y format.